star are of approximately equal brilliancy, they are of the same colour, and if of unequal brilliancy the colour of the fainter companion lies nearer to the violet end of the spectrum than does the colour of the brighter one. The spectra of the stars furnish a partial explanation of their difference in colour by showing, in at least some cases, that the stars possess spectra of different types, the fainter companion having a Sirian, and the brighter one a solar spectrum.

Few researches upon double stars exceed in theoretical interest the mathematical investigations of Mr. See with regard to the mode of development of these bodies. As early as 1878, Doberck had shown, from a statistical comparison of double star obits, that, in general, the longer the period of revolution of the compounds the larger and more eccentric are their orbits. That the orbits would be larger might be expected as a consequence of the law of gravitation, but it required a special investigation based upon the theory of tidal friction, as developed by Prof. G. H. Darwin, to show that the increasing eccentricities are also a necessary consequence of the same law. The conclusions of Mr. See may be briefly summarised as follows:—If we suppose the components of a double star to be composed of a plastic material, they will produce in each other bodily tides whose effect will be to push the stars asunder, and at the same time to increase the eccentricity of their orbits. This increase of eccentricity will not continue indefinitely, but in the later stages of developments will give way to a diminution of the eccentricities, which will ultimately produce circular orbits. But since the energy of the star is being constantly wasted by radiation, it will, in the later stages of its career, be reduced to invisibility, and during the period of its existence as a luminous body its history will present a continuous increase in the size and eccentricity of its orbit. It is of interest to note in this connection that the two orbits of spectroscopic binaries which have been computed, present eccentricities very much less than that of the average double star orbit, while the dimensions of their orbits are so small as to suggest an early stage in the development of the systems.

Prof. Wm. A. Rogers year by year brings to the Association either new and more refined apparatus, or the result of delicate experiments with the perfected apparatus already at his command. This year he presided over the Section of Physics, and read an elaborate address on obscure heat as an agent in producing the expansion of metals under air contact.

Vice-President Thomas H. Norton addressed the Chemical Section, on the battle with fire; Mansfield Merriman, the Engineering Section, on paradoxes in the resistance of materials; Samuel Calvin, the Geological Section, on some points in geological history illustrated in North-eastern Iona, exhibiting and using American chalk obtained from the Niobrora beds; Lucien M. Underwood, the Botanical Section, on the evolution of the Hepaticæ, a subject to which he has devoted especial attention, and on which he is probably the foremost authority; Franz Boas, the Anthropological Section, on human faculty as determined by race; and Henry Farquhar, the Economic Section, on a stable monetary standard.

One hundred and seventy-eight papers were read before the Sections, the largest number being before the Section of Anthropology.

It was decided to visit San Francisco next year if suitable rail rates can be secured, and the date of meeting recommended is June or early in July. Definite action, however, was deferred, owing to the expense of crossing the continent, so that time may be taken to apply for special rates of fare.

The following officers for the ensuing year were recommended by the nominating committee, approved by the council, and elected by the Association:—

President, E. W. Morley, Cleveland. Vice-presidents: Mathematics and Astronomy—E. S. Holden, Lick Observatory. Physics—W. Le C. Stevens, Troy, N.Y. Chemistry—William McMurtrie, Brooklyn, N Y. Mechanical Science and Engineering—William Kent, Passaic, N.J. Geology and Geography—Jed. Hotchkiss, Staunton, Va. Zoology—D. S. Jordan, Palo Alto, Cal. Botany—J. C. Arthur, Lafayette, Ind. Anthropology—F. H. Cushing, Washington, D.C. Economic Science and Statistics—B. E. Fernow, Washington, D.C.; permanent secretary, F. W. Putnam, Cambridge, Mass.; general secretary, James Lewis Howe, Louisville, Ky.; secretary of the council, Charles R. Barnes, Morrison, Wis. Secretaries of the Sections: Mathematics and Astronomy—E. H. Moore, Chicago, Ill.; Physics—E. Merritt, Ithaca, N.Y.; Chemistry—William P. Mason, Troy, N.Y.; Mechanical Science and Engineering—H. S. Jacoby, Ithaca, N.Y. Geology and Geography—J. Perrin Smith, Palo Alto, Cal. Zoology—S. A. Forbes, Champaign, Ill. Botany—B. T. Galloway, Washington, D.C. Anthropology—Mrs. Anita Newcombe McGee, Washington, D.C. Economic Science and Statistics—E. A. Ross, Palo Alto, Cal. Treasurer, R. S. Woodward, New York.

Wm. H. Hale.

THE IRON AND STEEL INSTITUTE.

THE summer meeting of the Iron and Steel Institute has been held this year, for the second time in the history of the Institute, in Belgium, the former meeting in that country having taken place at Liège just twenty-one years ago.

This year's meeting commenced on Monday, August 20, and continued until the following Friday. The President of the Institute, Mr. E. Windsor Richards, presided throughout. The proceedings commenced on the evening of the first day by a reception of members at the beautiful and historic Hôtel de Ville at Brussels, the civic authorities being the hosts. The proceedings were of an exceptionally successful character. On the following morning, Tuesday the 21st ult., the first sitting for the reading of papers was held. The following is a list of the contributions submitted:—

(1) "On the Use of Caustic Lime in the Blast-Furnace," by Sir Lowthian Bell.

(2) "On the History of Crucible Steel," by R. A. Hadfield.

(3) "On the Coal-mining Industry of Belgium," by A. Briart, President of the Society of Engineers, Hainaut.

(4) "On the Iron and Steel Industries of Belgium," by A. Gillon, President of the Society of Engineers, Liège.

(5) "On the Influence of Aluminium upon the Carbon in Ferro-Carbon Alloys," by T. W. Hogg, of the Newburn Steel Works.

(6) "On the Manufacture of Open Hearth Steel," by J. A. Lencauchez, Paris.

(7) "On Colour Gauges for Carbon Determination," by W. G. McMillan.

(8) "On Electrical Power in Belgian Iron Works," by D. Selby Bigge.

(9) "On the Manufacture of Coke," by the late R. de Soldenhoff.

(10) "On the Iron Ores of the Mediterranean Seaboard," by Arthur P. Wilson.

The papers of Mr. Hadfield and the late M. de Soldenhoff were taken as read.

The members were received in the Burse des Métaux, where the sittings were held, by M. Gillon and M. Briart, on behalf of the reception committee, and the usual complimentary speeches having been made, business was commenced by the reading of M. Gillon's paper. The title sufficiently indicates the scope of this contribution, and it is evident that an abstract such as, in any case, we could give here would be quite inadequate to so large a subject. The same remark applies to M. Briart's paper, which followed. Both contributions are of considerable interest from an industrial point of view: the first because the Belgians are such keen and successful competitors of our own iron and steel manufacturers in some branches of the industry, and the second from the fact that the coal-mining practice of the Belgians is of a very advanced character. Coal is won in Belgium often under conditions of extreme difficulty, such indeed as would cause despair to mining engineers in our own more favoured land, though doubtless we should rise to the occasion were the necessity put upon us. The natural obstacles which the Belgian engineers are forced to meet have necessitated the highest skill in mining practice, and we cannot but look with admiration at the patience, ingenuity, and skill displayed in the working of many collieries of the country. Sir Lowthian Bell's paper followed. The controversy regarding the respective merits of using caustic lime or raw limestone in the blast furnace is one of much antiquity, and though Sir Lowthian's paper did not perhaps do very much in itself to determine the dispute, it may be said that the paper and the discussion together served to determine the lines upon which the controversy should be carried on. The author said that in the older type of blast furnace it was a desirable thing to calcine the limestone separately, but with the higher furnaces now in vogue there

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was, on the balance, practically no advantage. In the discussion which followed, Mr. Charles Wood said that when iron ore and limestone were calcined together there was a distinct gain. We gathered from Sir Lowthian's reply to the discussion that he had not tried the plan Mr. Wood referred to—and which the latter had been following for twenty-five years—but that he would make further experiments on those lines. Perhaps the most striking feature in connection with this paper and discussion is its illustration of the value of societies of the nature of the Iron and Steel Institute. Here we have one practical detail which cheapens the cost of iron-making—at least, that is the opinion of a very competent ironmaster—in use for years, and it might have remained unknown to the majority of manufacturers had not the fact been elicited in this discussion. If Mr. Wood be right in his contention, he will doubtless receive confirmation from Sir Lowthian Bell at a subsequent meeting.

Mr. Hogg's paper followed, and in it were given the results of a large number of experiments, from which the author concluded that in the purer classes of iron the tendency of carbon to be retained in a combined state is prevented by the addition of 1 per cent. of aluminium, but curiously enough every increase above that percentage has an opposite tendency. It was also stated that the more rapidly cooled ferro-carbon alloys containing aluminium also contain a larger proportion of graphite. A short discussion followed the reading of this paper, and the meeting was then adjourned until the next day.

On the members reassembling on the following day, Wednesday, August 22, Mr. Selby Bigge's paper was first read. The author gave some interesting particulars of the progress that has been made in Belgium in using electricity as a means of distributing power in factories and workshops. The question has become one of commercial expediency, and the author boldly attacks it from this point of view, stating that his "whole contention in advocating electricity as the right and proper agent of operating new works, and as a means whereby old works can be remodelled, may be summarised by the one word 'economy.'" As an instance in point, he quoted the National Arms Factory at Herstal, near Liège. These works were recently founded to execute, in the first instance, an order for 200,000 rifles, the production being guaranteed at 250 rifles every twelve working hours. The Compagnie Internationale d'Electricité supplied the electric power installation, laying down thirteen motors, ranging between 16 and 37 horse-power, and giving a total of 260 horse-power. For the former size of motors they guaranteed a commercial efficiency of 87 per cent., and for the latter 89 per cent. The total power of the motors (260 horse-power) would therefore be obtained by 296·9 initial horse-power. There was a large amount of electric lighting to be done also, so that an engine and dynamo of 500 horse-power was installed. The ratio between the electric energy available and the energy transmitted to the shaft by the engine was guaranteed to be 90 per cent. The electric motors drive the line shafting of the machines, and the efficiency of transmission—that is to say, the ratio between the power available and the effective horse-power developed by the steam engine—is given by the product of three efficiencies, as follows: —90 per cent. for the dynamo, 98 per cent. for the conductors, and 87 per cent. for the motors = 76·6 per cent. The installation has now been running for three years without being the cause of cessation of work for a single minute.

It is a very difficult matter to form comparisons between the respective efficiencies of different methods of power distribution, and it may be pointed out that in the Herstal case the electric system does not appear to its greatest advantage, as the motors drive line shafting in place of being attached directly to the machines. There is no doubt, however, that a very strong case can be made out for electricity, and electrical engineers may look forward with confidence to a large extension of their field of activity in regard to power distribution.

The paper of M. Lencauchez dealt with a novel description of open hearth furnace in which jets of air and gas appear to be blown on the bath of molten metal to assist oxidation. The device did not receive much commendation in the discussion which followed the reading of the paper, but in the absence of illustrations referred to by the author, it was very difficult for those who had not had the advantage of seeing the furnace to follow the description.

The paper of Mr. McMillan, on colour gauges, was read in brief abstract, and Mr. Wilson's paper was also considerably curtailed in delivery, the time of the meeting having expired.

There were several excursions in connection with the meeting. The first, on the Tuesday afternoon, was to the Antwerp Exhibition, and on Wednesday evening members were received by the King of the Belgians, at the Royal Palace in Brussels. This was the chief feature of the meeting, the King receiving his guests in person, and apparently thoroughly enjoying the many conversations he had with the English metallurgists and engineers present. On the Thursday and Friday of the meeting, visits were paid to steel works, collieries, glass works, and engineering establishments. The last excursion on the list was to the important works known as the Société Cockerill at Seraing, near Liège. These works date from the beginning of the century, having been founded by a British subject, we believe a Scotchman. At present 5500 workmen are employed. According to particulars given to members in the shape of a handbill, there are five blast furnaces, an open steel plant, a basic steel plant, 250 coke ovens, 40 puddling, 15 reheating furnaces, 10 rolling mills, 3 foundries, 9 winding engines, 5 pumping engines, 4 blowing engines, 28 engines for rolling mills, 204 machine tools, 14 locomotives, and 184 steam boilers supplying 17,000 horse-power. The Company has also a shipbuilding establishment at Hoboken.

PHYSIOLOGY AT THE BRITISH ASSOCIATION.

THE meeting of the Association this year was a memorable one for physiology, since this subject was for the first time placed by the Council on an independent footing. This action of the Council has been amply justified by the success of the new Section I, there being a very representative attendance of English and continental physiologists, and great wealth of material for their consideration. The number of papers was so large that even when the sittings were extended to the final Wednesday morning, the business of the Section could only be got through with difficulty, and the opinion of all concerned was emphatic as to the high quality and great interest of many of the communications. In addition to the sectional meetings, advantage was taken of the presence of so many physiologists to dovetail a meeting of the Physiological Society into the proceedings; this was held on Saturday afternoon, when several interesting communications were made, and the meeting was followed by the dinner of the Society in Magdalen College, under the presidency of Prof. Burdon Sanderson.

The following summary will furnish a general account of some of the chief points in the many varied papers read before this Section:—

Thursday, August 9.—The proceedings opened with a communication by Mr. M. S. Pembrey, on the reaction of animals to changes of external temperature. The observed reaction was that of the production of heat, this being estimated by the amount of CO_2 discharged from the animal. Experiments upon the mouse were described, which showed that in proportion as the external temperature was lowered, the CO_2 output of the animal was rapidly increased (in one minute the increase amounted to 60 per cent. when the temperature fell from 33° to 17° C.), and concurrently with this increase the animal's muscular activity became far more vigorous. Experiments made upon the developing chick showed that up to the twenty-first day the effect of external cold was to decrease the CO_2 output, the chick in this stage behaving like a cold-blooded animal, but that a comparatively sudden change took place from this day onwards, the chick reacting like the warm-blooded animal previously referred to. This change in reaction is probably related to the development of the neuro-muscular mechanisms, and is undoubtedly influenced by the activity of the animal. Observations made upon newly-hatched pigeons showed that these birds, being more or less helpless when hatched, react for the first few days like cold-blooded animals, the output of CO_2 decreasing with a fall in the external temperature; it is probably for this reason that these young birds are kept warm by the parent until their muscular activity is more developed. The influence of the muscular activity upon the production of heat was further shown by details of observations made upon mice after section of the spinal cord, as well as during anæsthesia; in both cases the muscular paralysis was accompanied by a change in the reaction, which now resembled that of a cold-blooded animal.

Mr. Harris described the results of an investigation into the

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